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Note

A Modified Power Tiller for Metham Application on Cucurbit Crops Transplanted to Polyethylene-Covered Seedbeds[1]

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Abstract: Metham has been reported as an acceptable weed control alternative to methyl bromide. However, modified application equipment is required to allow its effective use in crops that are grown on polyethylene-covered seedbeds. A power tiller was modified using commonly available materials to apply metham in a 61-cm band and shape seedbeds for laying a black polyethylene tarp. Additional modification allowed the implement to be used in strip tillage and conventional tillage systems. Metham applied using this modified power tiller effectively controlled many species of weeds, including yellow nutsedge, in transplanted watermelon.

Nomenclature: Metham; yellow nutsedge, *Cyperus esculentus* L. CYPES; watermelon, *Citrullus lanatus* (Thunb.) Mansf.

Additional index words: Alternatives to methyl bromide, fumigation.

Abbreviations: PPI, preplant incorporated; PRE, preemergence; PTO, power take-off.

INTRODUCTION

Cucurbit crops are grown on approximately 22,000 ha in Georgia, with watermelon and cantaloupe (*Cucumis melo* L.) accounting for 75% of the area (Bass 1999). In previous years, most of the watermelon and cantaloupe acreage was direct-seeded on freshly prepared seedbeds. Recently, systems using hybrid cultivars seeded in greenhouses and transplanted into the field have become more common. Hybrid seeds are costly, and transplanting reduces the risk of stand loss associated with direct seedings caused by an assortment of early-season production problems. Polyethylene-covered seedbeds are generally fumigated with a broad-spectrum fumigant, particularly methyl bromide.

Methyl bromide fumigation controls most pests of cucurbit crops, including annual and perennial weeds, pathogenic fungi, bacteria, plant parasitic nematodes, and soil-inhabiting arthropods. Several weeks before seeding or transplanting, methyl bromide is injected approximately 20 cm deep and immediately covered with a black polyethylene tarp that forms a finished seedbed approximately 30 cm wide. The polyethylene-covered seedbeds used in this system can be irrigated with overhead systems and are normally used for only one crop. Polyethylene-covered seedbeds that are $>$ 76 cm wide are treated in a similar manner but use drip irrigation and can be planted to multiple crops in a season. In both systems, seedlings are transplanted through the polyethylene tarp at 2 to 4 wk after fumigation to allow dissipation of methyl bromide.

Methyl bromide is thought to contribute to the depletion of stratospheric ozone (Anonymous 1998). Therefore, the U.S. Environmental Protection Agency initiated a mandatory phase-out of all methyl bromide–containing fumigants by 2005 (Noling and Becker 1994; USDA 1999). Csinos et al. (1997, 2000) found several acceptable alternatives to methyl bromide in tobacco (*Nicotiana tabacum* L.), tomato (*Lycopersicon esculentum* Mill.), and bell pepper (*Capsicum annuum* L.) transplant production. They showed that metham at 666 L/ha (broadcast rate) was as effective as methyl bromide at 650 kg/ha in controlling several cool-season weeds. Sequentially applying metham with 1,3 dichloropropene (1,3-D) and/or chloropicrin (trichloronitromethane) improved the control of pathogenic fungi, bacteria, plant parasitic nematodes, and soil-inhabiting arthropods. Because of the chemical incompatibility of the fumigants, each must be applied separately. Both 1,3-D and chloropicrin were injected 20 cm deep before metham was sprayed and incorporated with a power tiller. All plots were immediately covered with a polyethylene tarp after fumigation.

These studies inferred that growers could customize the fumigant combination according to the pests present in the soil. For example, metham alone is an excellent

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Figure 1. Overall view of Ferguson Tillervator® modified for banded applications of metham in transplanted watermelon on polyethylene-covered seedbeds.

herbicide capable of killing dormant weed seeds (Teasdale and Taylorson 1986) and fungicide (Cline and Beute 1986). Furthermore, 1,3-D and/or chloropicrin are poor herbicides but effective nematicides. Coupled with the innate differential selectivity of the fumigants are the different types of application for optimum efficacy. Metham is applied by chisel-plow 20 cm deep for control of root diseases of peanut (Cline and Beute 1986) but provides little weed control when applied in this manner. In contrast, metham applied as spray and incorporated to a depth of 7.6 cm gives excellent weed control, but is less effective on root diseases than chisel-plow applications.

The fumigant combinations that may serve as replacements to methyl bromide give growers opportunities for broad-spectrum pest control. However, the narrow pest control spectrum of individual fumigants and the differences in optimum application techniques make integration of these fumigants into cucurbit cropping systems difficult. Because metham is effective for weed control in tobacco plant beds, efforts were made to modify an implement to apply metham for weed control in transplanted cucurbits.

DESCRIPTION OF IMPLEMENT

Metham should be applied and positioned in the soil profile where the pest is located (Anonymous 1999). This suggests that metham should be placed where weed seeds germinate and emerge, which is generally the top 7.6 cm of the soil profile. Most preplant incorporated (PPI) herbicides used in agronomic and vegetable crops are sprayed and uniformly incorporated to a depth of 5.1 to 7.6 cm using shallow tillage implements, such as a power tiller.

A Ferguson Tillervator®[3] (180 cm wide) was used as the basis on which our modified tiller was built (Figure 1). The tiller mounts to a tractor with a three-point hitch using Category-I hitch pins. This tiller had multiple gangs of C-shaped tines that operate off the power take-

[3] Ferguson Manufacturing Company, Suffolk, VA 23234.

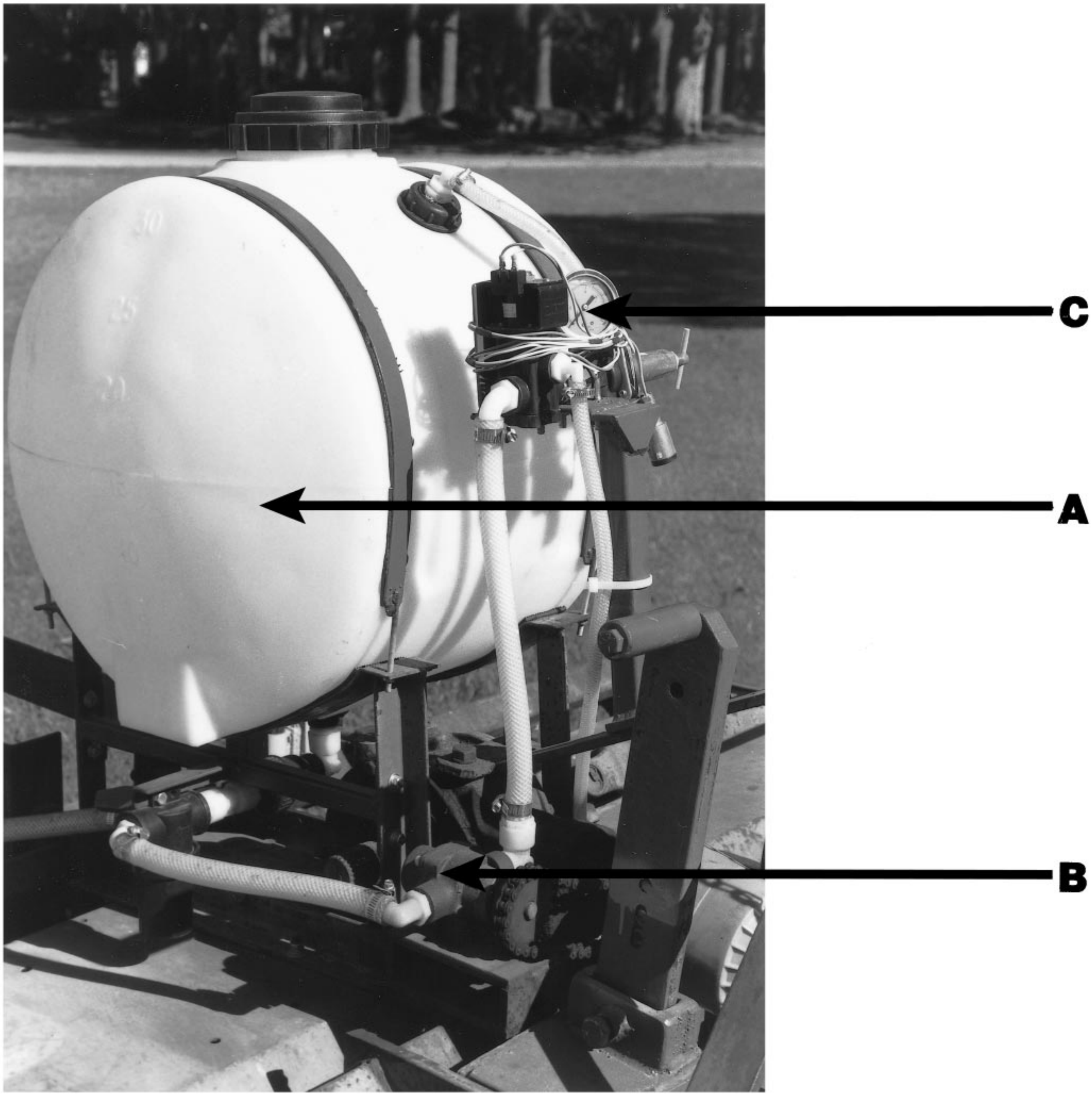

Figure 2. Sprayer apparatus on modified power tiller: (A) spray tank and mounting hardware, (B) chain-driven roller pump, (C) solenoid switches and pressure regulator.

off (PTO) of a tractor. The tiller is designed to operate at a PTO speed of 540 rpm. A chain sprocket attached to the main drive shaft can be used to operate a sprayer pump (Figure 2). In addition, the tiller has a mounting frame on top of the deck for a spray tank and tool bars immediately anterior and posterior to the tiller housing for mounting additional devices. Two 41-cm-gauge wheels are mounted 1.8 m apart on the front tool bar to stabilize the depth of tillage (Figure 3A).

All C-shaped tines were removed, except for a gang in the middle set to till a swath 61 cm wide (Figure 4A). This is a common width of treated seedbeds in transplanted cucurbit crop production. A 114-L spray tank was mounted on the top of the tiller deck using the existing frame (Figure 2A). A Model 4101-N Hypro®[4] roller pump was added (Figure 2B), with maximum output of 26.5 L/min operat-

[4] Hypro Corp., New Brighton, MN 55112.

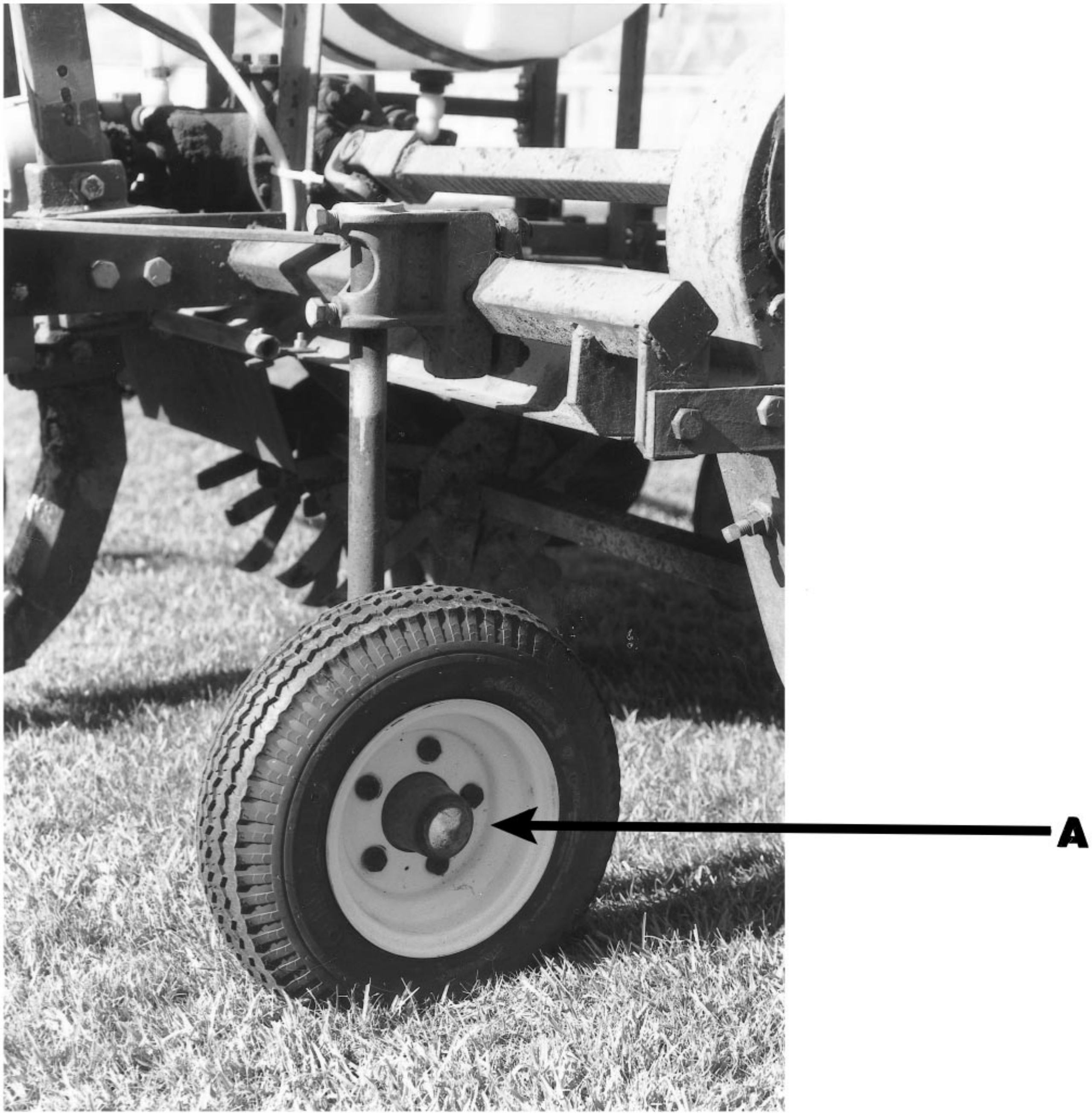

Figure 3. (A) Gauge wheels mounted on anterior tool bar of modified power tiller to stabilize depth of tillage.

ing at a PTO speed of 2,600 rpm at 1,035 kPa. However, the pump operating at maximum capacity would have produced excessive bypass volume in our system. The pump was operated at a PTO speed of 540 rpm and 166 kPa, which reduced the output to 2.4 L/min. Supply and bypass hoses, pressure controls, and solenoid sprayer controls were added (Figure 2C). A single nylon Delavan D5®[5] flood jet nozzle was mounted 15 cm in front of the tiller tines and adjusted to a height to treat a band width of 61 cm (Figure 5A). A steel plate (53 by 15 cm) served as a shield between the spray nozzle and the tiller tines, preventing tilled soil from disrupting the spray pattern (Figure 5B). The sprayer was calibrated to apply nondiluted metham (Vapam HL®;[6] 2.5 kg ai/L) at 666 L/ha (broadcast basis) by adjusting the ground speed to 0.9 m/s. A power tiller normally operates at a ground speed of 1.3 m/s (Thompson et al. 1981).

The power tiller was also modified with features for

[5] Delavan-Delta, Inc., Lexington, TN 38351.

[6] AMVAC Chemical Corp., Newport Beach, CA 92660.

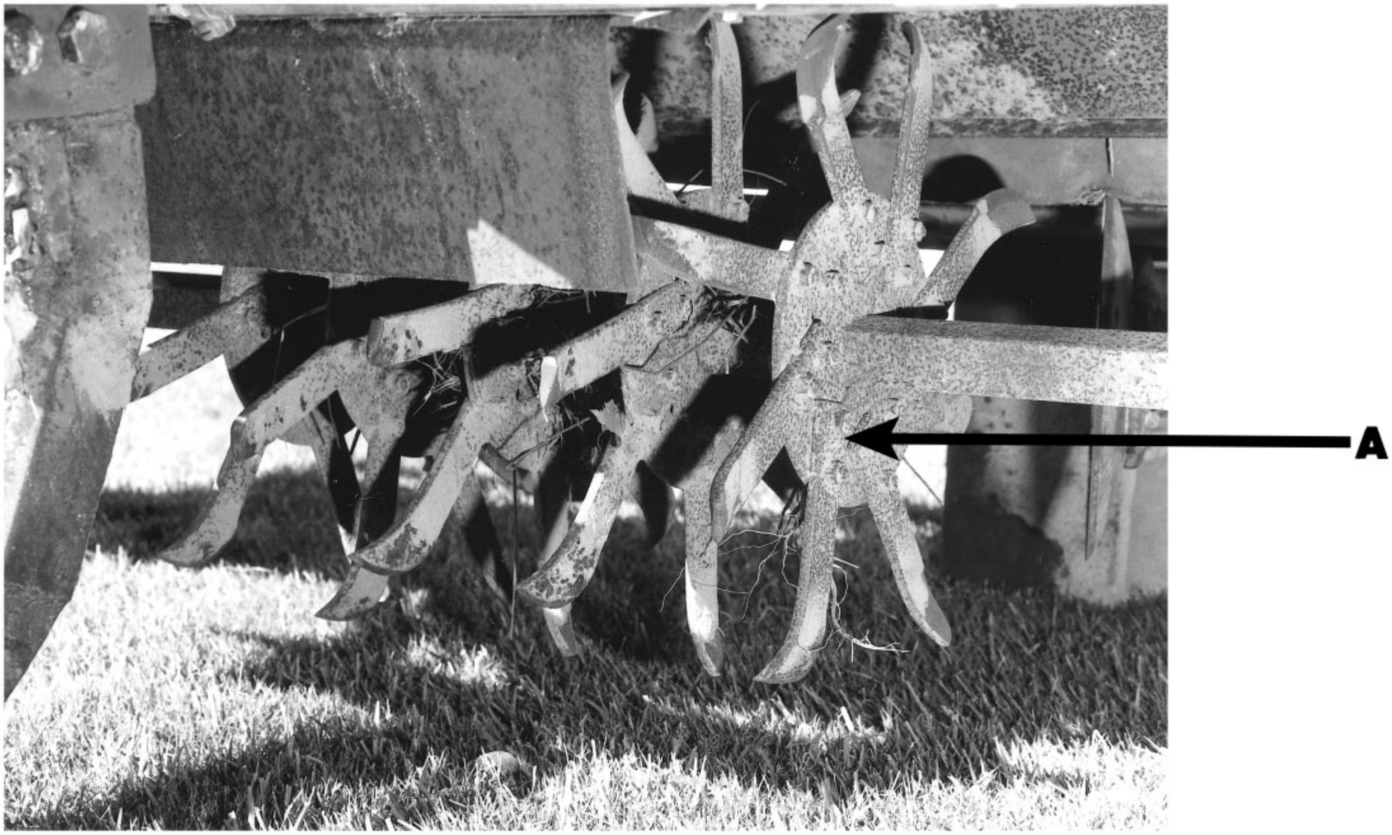

Figure 4. (A) Gang of C-shaped tines set to till a band width of 61 cm. Extra tines were removed.

use in strip tillage research. These included a 36-cm fluted coulter with spring-adjustable tension controls (Figure 6A) and a subsoil shank mounted anterior to the power tiller (Figure 6B). A steel frame (Figure 6C) was fabricated to mount the subsoil shank and fluted coulter to the tiller, giving ample clearance beneath the PTO shaft. The subsoil shank mounting bracket had height adjustments for depth of in-row subsoiling (Figure 6C), with a maximum depth of 43 cm.

Attached to the rear tool bar were two conical-shaped hiller disks (30-cm diam) angled to define the width of the seedbed (Figure 7A). The hiller disks were mounted 61 cm apart, with height adjustments for each disk. Shaping the seedbeds facilitated the laying of polyethylene tarp, which was done as a separate operation. Posterior to the hiller disks was a steel plate, 94 by 30 cm (Figure 7B). This plate was mounted with spring-adjustable tension controls to level and smooth the seedbed after tillage, sealing the soil with a light crust.

INITIAL FIELD TRIALS

Several practice sessions were conducted on border areas to determine if adjustments were needed in settings, balance points, and spring tensions. After optimum set-up was determined, the modified power tiller was used at the Coastal Plain Experiment Station Bowen Farm in the eastern portion of Tift County, GA. This is the site of a long-term integrated pest management study in an all-vegetable crop rotation under four one-tower center pivot irrigation systems. Each center pivot covers 0.6 ha. The trials were initiated in 1998, with 1999 being the first year for transplanted watermelon in the rotation. Half of each center pivot was planted to watermelon in 1999 and 2000, for a total watermelon planting among the four irrigation systems of 1.2 ha.

The soil type was an Ocilla loamy coarse sand (aquic, Arenic Paleudults) with 96% sand, 2% silt, 2% clay, and 0.7% organic matter. The site has a very heavy natural infestation of yellow nutsedge (*Cyperus esculentus* L.).

The long-term research project conducted at this site has two treatment factors: tillage and cultivar. The tillage variables were conventional tillage (deep tillage and harrowing for each crop in the rotation sequence) and strip tillage into a killed rye (*Secale cereale* L.) cover. Conventional tillage plots were harrowed and deep turned 35 cm deep in May each year. Strip tillage plots were treated with glyphosate (1.1 kg ai/ha) plus ammonium sulfate

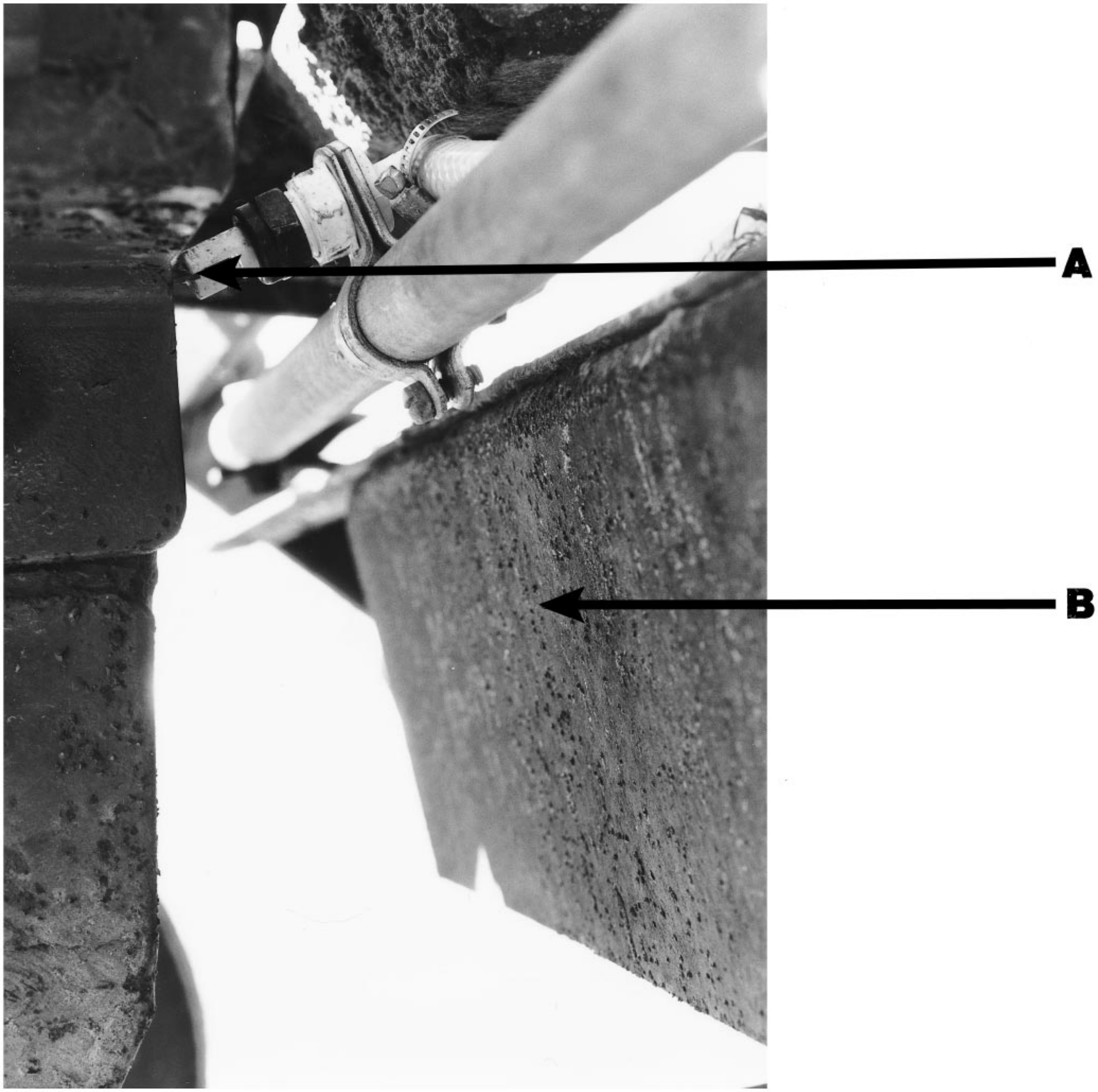

Figure 5. (A) Single flood-jet spray tip, (B) metal shield protecting spray pattern from disruption by tilled soil.

(0.1 kg/L) in late March to kill the rye cover crop. Seedlings were established in Speedling®[7] trays in a greenhouse in early May.

Concurrent with seedling establishment in the greenhouse, plots in the field were prepared for metham application. The experimental site received 0.5 cm rainfall 1 d before metham application in 1999. In 2000, the plots were irrigated before treatment. Metham was applied to all plots in early May both years using the modified power tiller. Immediately after metham application, 1-mil black polyethylene tarp (61 cm wide) was spread in a separate operation, making a finished seedbed 30 cm wide. Treated seedbeds were spaced 1.8 m apart. Plots remained covered with the polyethylene tarp for the duration of the cropping season.

After a 21-d period to allow metham to dissipate, watermelon seedlings were transplanted using a Kennco®[8] transplanter that punches holes 0.9 m apart in the poly-

[7] Hummert International, Earth City, MO 63045.

[8] Kennco Manufacturing Inc., Ruskin, FL 33570.

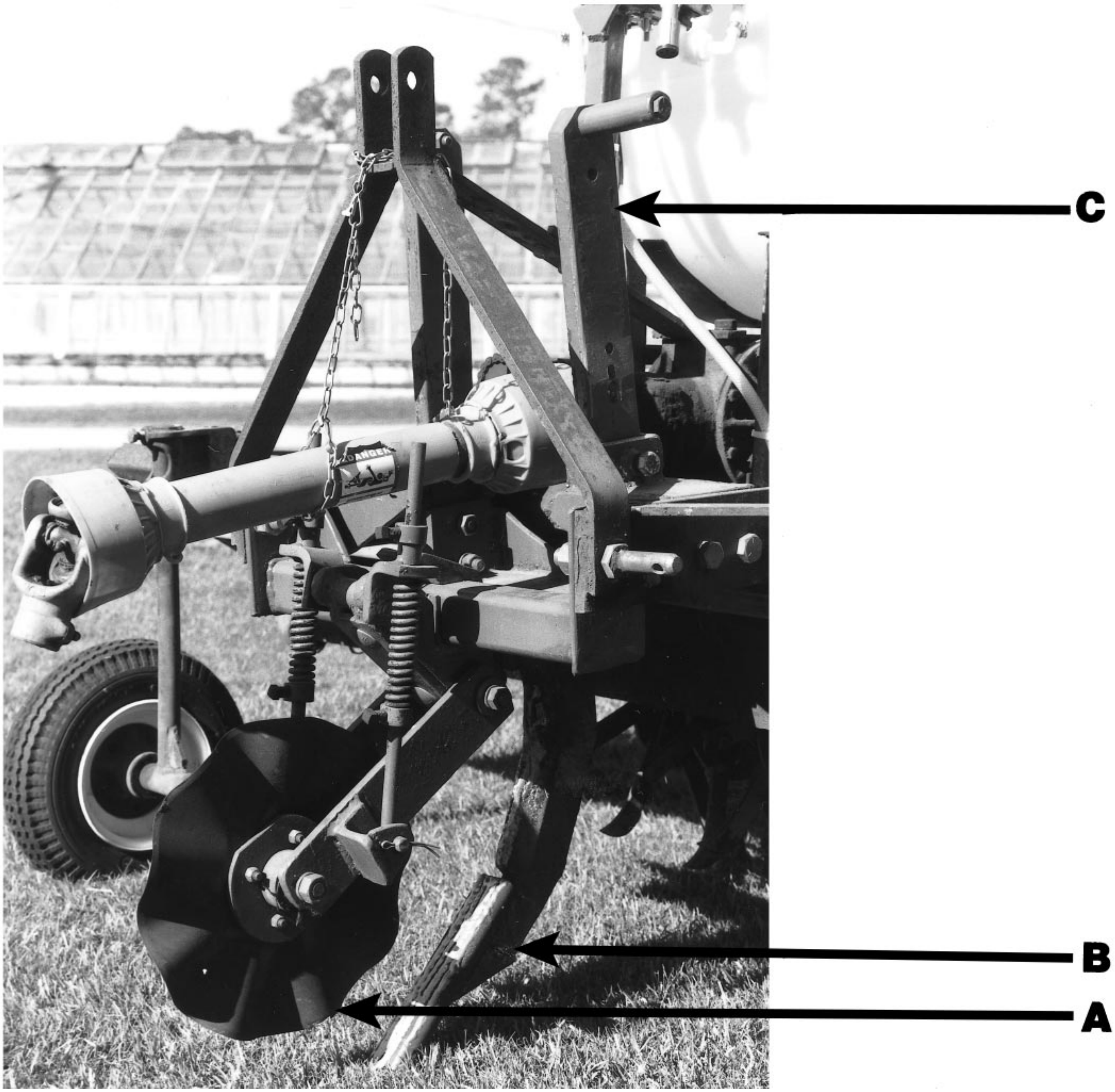

Figure 6. Anterior view of modified power tiller showing (A) fluted coulter, (B) single in-row subsoil shank, (C) mounting bracket allowing clearance beneath PTO shaft.

ethylene tarp and transplants in one operation. Maintenance weed control the remainder of the season consisted of paraquat (0.5 kg ai/ha) plus ethalfluralin (0.6 kg ai/ha) plus halosulfuron (36 g ai/ha) applied preemergence (PRE) immediately before transplanting. Just prior to watermelon vines running, glyphosate (1.1 kg/ha) plus ammonium sulfate was applied with a shielded sprayer. PRE herbicides and glyphosate were directed to the shoulders of the polyethylene-covered seedbeds and into row middles. No herbicide came in contact with watermelon plants.

The modified power tiller performed flawlessly in both conventional and strip-tilled plots. Subsoiling was performed on conventional tillage plots, as well as strip tillage plots. The combination of bed shapers and steel leveling plate produced a well-shaped, smooth seedbed. No problems were encountered in laying the polyethylene tarp because of the quality of the seedbed produced

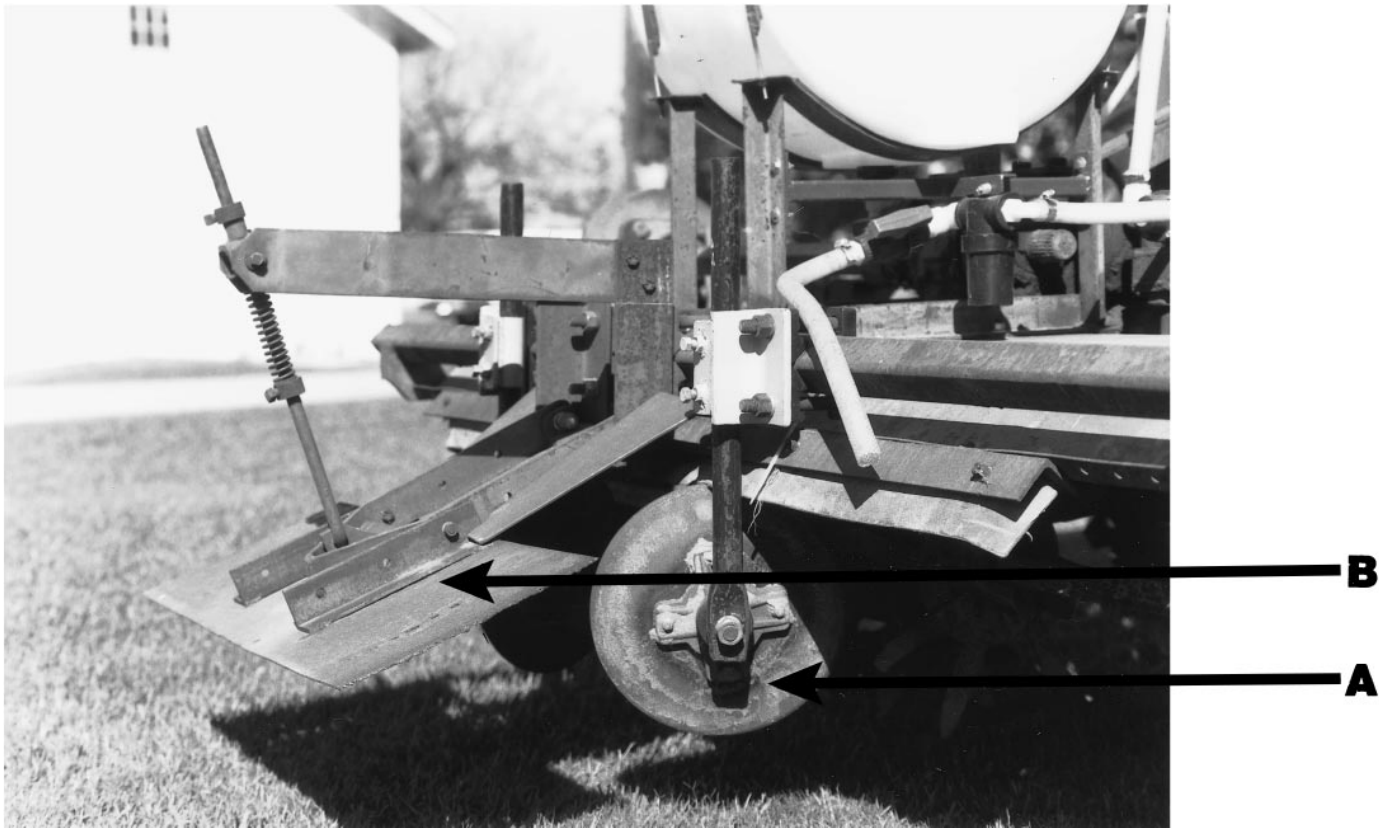

Figure 7. Posterior view of modified power tiller showing (A) hiller disks to shape seedbeds after tillage and (B) steel plate to smooth tilled seedbed, sealing the seedbed with a light crust.

by the modified power tiller. The modified tiller also performed well in strip tillage plots, where the combination of fluted coulter, power tiller, and seedbed leveler prevented cover crop debris from interfering with laying the polyethylene tarp.

Weed control under the polyethylene tarp was exceptional across all plots, with no phytotoxicity to watermelon. Metham applied in this fashion and immediately covered by the polyethylene tarp for 21 d effectively controlled all weeds, including yellow nutsedge. Very few yellow nutsedge plants emerged from metham-treated soil and penetrated the polyethylene tarp at the time of watermelon transplanting (data not shown). Midseason weed counts were made August 13, 1999, just prior to watermelon harvest. Across all tillage treatments and cultivars, which covered a 1.2-ha area, there was an average of 2.7 yellow nutsedge shoots/m^2. In contrast, nontreated areas adjacent to the research site averaged 88 yellow nutsedge plants/m^2. Similar results were seen in 2000.

These weed counts were made with a counting frame (1.0 by 0.5 m) placed adjacent to the crop, with part of the counting frame on the polyethylene bed adjacent to the drill and on noncovered soil between rows. These data reflect the combined weed control effects of metham, black polyethylene tarp, PRE herbicides, and glyphosate. However, successful weed control with this system is due in part to metham applied with the modified power tiller.

Considering the large area treated, the excellent performance of metham applied with the modified power tiller is a significant discovery. First, the implement was a modification of commonly available equipment using readily available stock materials. Modifications were not contracted to commercial machine shops and are well within the skill of many growers. Second, the modified implement was successfully used in strip-tilled cucurbit crop production, with no adverse effects of cover crop debris on seedbed preparation and spreading of the polyethylene tarp. Third, metham was successfully applied for weed control in watermelon by placing it in the upper strata of the soil profile, where most of the weed seeds and yellow nutsedge tubers are located.

This procedure was performed under the premise that metham applied for weed control is similar to other herbicides applied PPI, and efficacy is dependent on uniform soil incorporation. Metham has been used in the southeastern United States for peanut (*Arachis hypogaea* L.) root disease control using chisel plow–injected applications, which does not control weeds because of reduced rates and deep placement in the soil profile. Changing the application technique by using an implement similar to our modified power tiller will allow metham to be used in a manner that will maximize its utility as a herbicide in transplanted cucurbit crop production and, from the weed control perspective, will serve as an alternative to methyl bromide.

FUTURE MODIFICATIONS

Csinos et al. (1997, 2000) reported broad-spectrum control of many pest groups with metham sequentially applied with 1,3-D and/or chloropicrin. This required injecting 1,3-D, chloropicrin, or both below the soil surface but before metham application. The subsoil shank on our modified tiller is a possible means by which 1,3-D, chloropicrin, or both can be sequentially applied with metham. Potential modifications would be multiple injection ports added to the subsoil shank and metering devices for gaseous fumigant application.

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